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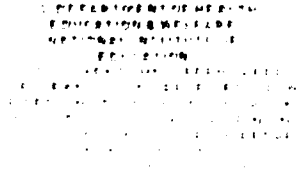
ABSTRACT

This study was undertaken to determine students' views of their experiences in studying the basic sciences in first year medical school. Emphasis was placed on the processes of learning employed. An instrument was developed consisting of verbs or phrases describing various behaviors performed by a scientist when doing science. Such activities included observation, measurement, hypothesizing, predicting, interpreting data and other mental and tactile operations. The instrument was administered to students at the end of their first year. They were asked to rate each operation on: (1) its importance for medical and dental students; and (2) the extent to which they actually did perform each activity as a result of their involvement in the Basic Medical Sciences curriculum. Data were analyzed using a two-way multi-variate analysis of variance, with the principal contrasts consisting of medical versus dental students and ideal versus actual experience. Striking differences between the two sets of ratings were observed indicating that many of the processes judged important were not commonly exercised during the first year of study. It seemed that students' perception of their actual experience was learning about science by memorizing and organizing great bodies of information. (Author/ED)



LEARNING PROCESSES IN A BASIC SCIENCES CURRICULUM

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Why do medical students study the basic sciences? There are two common arguments. The first deals with the development of the "scientific physician," the doctor who can use the scientific method in his daily practice. Such a doctor is contrasted to one who performs by rote, who has been trained rather than educated. Advocates of the Problem Oriented Record often contrast the rigor and humility of the scientist at the bench with the slipshod and non-systematic manner in which medicine is sometimes practiced. Formulating problems in an intellectually honest way in accordance with one's understanding of the data before him is fundamental to the problem oriented system. They are essentially reaffirming their faith in the value of the scientific method to the daily practice of medicine. Since the basic scientist is a model of scientific behavior, might not one expect that students exposed to such individuals for long periods of training and coursework would emerge firmly skilled in such scientific habits? Or so one might expect if this argument was followed to a logical conclusion.

Another argument is that studying the basic sciences equipps the student with the language of those sciences in which advances of a fundamental nature are currently being made so that the student can understand such advances when they occur. The basic sciences would not be taught and studied so much as a set of answers about underlying mechanisms which have direct clinical application but as areas of inquiry of a very fundamental nature where investigations are still underway. The doctor would be educated as an intelligent consumer, able to accept answers as they occur and willing to explore their usefulness to his practice.

There are other arguments, but if we limit consideration to these two, we might summarize as follows. Position one calls for familiarity with the

scientific method in order to develop a scientific approach to problem solving, that is, learning to DO science. Position two emphasizes learning the language of science and appreciating science so that the doctor will be able to consume and apply the findings of basic research to his own practice of medicine. Position one prescribes that students learn to DO science, while position two prescribes that students learn ABOUT science.

The current study was undertaken to determine students' views of their experiences in studying the basic sciences. It is one thing to listen to rhetoric about the importance of studying the basic sciences, but impact on students of such study may be something entirely different.

One impact, the mastery of large bodies of knowledge, is already clear. Using standard measures of learning such as the Part 1 of the National Board examinations, it is apparent that students learn a good deal during their first two years. The University of Illinois at Chicago has given a pre-test to entering students for several years. The pre-test is pretty much a parallel form of the first year comprehensive examination typically given at the end of the first year of medical school. Quite consistently, despite the impressive educational backgrounds of the incoming classes, only a few students have managed to qualify on the pre-test and pass out of the first year of medical school. Nine months later all but a few of these same students pass a similar examination. Despite the absence of a control group, this is convincing evidence that students did learn a considerable amount during their first year of study.

I am really not trying to question this conclusion and would be highly surprised to find somebody who would seriously question the amount of learning which takes place during that busy first year. Besides the issue of how much is learned, however, one can also ask about learning processes, and how students learned.

What processes did students employ consistently during their first year of study? We know they learned a good deal ABOUT science, but how much science did they DO?

To answer this question, I developed an instrument consisting of some 20 verbs or phrases which, in my opinion, describe some of the behaviors performed by a scientist when he DOES science. Many of these activities are familiar to those of you who do research or have youngsters working with the AAAS sponsored science curriculum, "Science, A Process Approach."

What does the scientist do when he is doing science?

He observes, measures, hypothesizes, predicts, interprets data, defines operationally, and performs a number of other mental and tactile operations.

I submitted a list of 20 such activities to last year's first-year class at the end of their first year and asked them to rate each operation according to: 1) its importance for medical and dental students; that is, the extent to which they OUGHT to be engaged in each activity; 2) the extent to which they actually did perform each activity as a result of their involvement in the Basic Medical Sciences curriculum. They used a scale of 1 to 6 (low to high).

Results

Table 1 shows the average rating of each activity for both medical and dental students, first with respect to the perceived importance of that activity, Columns 1 and 2, and secondly with respect to how characteristic that activity was of their experience during their first year of study, Columns 3 and 4.

INSERT TABLE 1 HERE

These data were analyzed using a two-way multi-variate analysis of variance, with the principal contrasts consisting of medical versus dental students and Ideal versus Actual experience on all twenty of the activities which were rated.

When medical and dental students are compared in terms of their ideal ratings, only two are different enough to be statistically significant in a univariate sense: synthesizing and problem solving.

Another three are rated differently by medical and dental students in terms of their actual experience: communicating, inferring, and organizing. On the whole, however, medical and dental student perceptions are extremely similar, and it is gratifying that this was the case with respect to their actual experience because they had undergone virtually identical educational experiences, and it would have been terribly embarrassing if it had turned out otherwise. Upon replication this year, none of these differences occurred; i.e., the incidental differences described above did not re-occur during this year's testing, and the major differences described below were found to be stable.

The differences which are striking and which are statistically significant in both a multivariate and univariate sense are those differences which compare Ideal to Actual experience. These differences hold for both medical and dental students and are summarized in Table 2. The means for medical and dental students' Ideal rating are shown in Column 1 and the means for their Actual ratings are shown in Column 2, with the differences in Column 3. The only difference which is not statistically significant is that of variable 2, Classifying.

INSERT TABLE 2 HERE

Discussion

In examining Table 2, there is one striking result. Actual experience in the scientific behaviors was rated lower than these same behaviors had been rated in importance for the future physician or dentist. Memorizing was the only behavior on which students rated their actual experience as being above the ideal level.

Where do the largest discrepancies exist between students' Ideal and Actual ratings? In decreasing order of magnitude the largest differences exist between the Ideal and the Actual ratings on: Applying (-1.92), Communicating (-1.39), Problem Solving (-1.35), Making Judgements (-1.30), Formulating Hypotheses (-1.24), Interpreting Data (-1.12), Memorizing (+1.09). It is also evident that these same processes were rated high in Ideal importance, with the exception of Memorizing, and that most students did find discrepancies between their ideal ratings and their actual experience in studying the basic sciences.

Applying and Communicating, in fact, had the highest Ideal rating and there does seem to be a certain amount of face validity to the importance of these skills to the physician or dentist. Problem Solving, Making Judgements, and Interpreting Data have high ideal ratings which would indicate that medical and dental students are biased toward the ideal of the Scientific physician or Scientific dentist, that is, what we described earlier as position one. What they experience, however, is a "position two" education as evidenced by the large discrepancies between the ideal and actual ratings, and especially by the ratings assigned to Memorizing. Memorizing received the second lowest Ideal rating and the highest Actual rating. While students view Memorizing as least important, it is most characteristic of their actual educational experience.

What about the smallest discrepancies? The smallest discrepancies occurred on the following processes: Classifying (-.05), Using Numbers (-.45),

Organizing (-.56), Inferring (-.66), Using Space/Time Relationships (-.67), and Measuring (-.27). Of these, Classifying and Organizing were rated fairly high in importance Ideally, so that the small difference between Ideal and Actual rating would indicate that students do experience lots of opportunity to Observe and Organize during their first year of study. For the numerically related processes, however, the ratings were uniformly low to begin with and even lower in terms of actual experience. Using Numbers, Using Space/Time Relationships, and Measuring, are neither rated that high in terms of what the future physician and dentist is thought to need, nor are they experienced much during the first year of study.

Because of the low ratings assigned to the behaviors dealing with quantitative skills, I just scanned the March 15, 1974 issue of Science and found every scientific article and report decorated with tables, graphs, scales, formulae and other quantitative translations of the results. The syllabus for our first year students also contains a fair amount of quantitative material. It is difficult, in fact, to think of actively doing science without heavy reliance on quantitative skills. The most obvious conclusion seems to be that students in their first year DO very little science. Rather they memorize, organize, and learn ABOUT science.

Summary and Conclusions

First year medical and dental students were asked to rate 20 scientific processes in terms of their importance for future physicians and dentists and also in terms of the extent to which students had opportunities to perform these processes during their first year of study in the Basic Medical Sciences curriculum. Striking differences between the two sets of ratings were observed indicating that many of the processes judged important by them were not commonly exercised during the first year of study.

Returning full circle to the question raised in the opening section of the paper about reasons for studying the basic sciences, it would seem that students' perception of their actual experience is not that of becoming familiar with the processes basic to the scientific method, Classifying and Organizing norwithstanding, but rather of learning ABOUT science by Memorizing and Organizing great bodies of information.

TABLE 1

AVERAGE STUDENT RATING OF LEARNING PROCESSES

	IDEAL		ACTUAL	
	Medical	Dental	Medical	Dental
1. OBSERVING	4.8	5.0	3.9	4.2
2. CLASSIFYING	3.8	3.6	3.6	3.7
3. USING NUMBERS	2.7	2.2	2.1	1.9
4. MEASURING	3.1	3.0	2.4	2.2
5. USING SPACE/TIME RELATIONSHIPS	3.7	3.4	3.1	2.6
6. COMMUNICATING	5.3	5.2	3.5	4.2
7. PREDICTING	4.3	4.3	3.3	3.5
8. INFERRING	4.2	4.4	3.4	4.0
9. DEFINING OPERATIONALLY	4.5	4.9	3.5	4.1
10. FORMULATING HYPOTHESES	4.5	4.5	3.2	3.3
11. INTERPRETING DATA	4.8	4.6	3.5	3.7
12. CONTROLLING VARIABLES	4.0	3.5	2.8	2.9
13. EXPERIMENTING	3.7	3.4	2.6	2.6
14. MEMORIZING	3.4	3.5	4.3	4.7
15. ORGANIZING	4.8	5.0	4.0	4.7
16. APPRAISING	4.6	4.3	3.5	3.9
17. SYNTHESIZING	4.9	4.2	3.8	3.3
18. PROBLEM SOLVING	5.3	4.5	3.6	3.6
19. MAKING JUDGEMENTS	4.9	4.7	3.4	3.6
20. APPLYING	5.3	5.5	3.3	3.6

TABLE 2

COMBINED RATINGS OF MEDICAL AND DENTAL STUDENT LEARNING PROCESSES

		IDEAL	ACTUAL	DIFFERENCE*
1.	OBSERVING	4.949	4.117	- .83
2.	CLASSIFYING	3.727	3.677	- .05
3.	USING NUMBERS	2.504	2.050	- .45
4.	MEASURING	3.051	2.331	- .72
5.	USING SPACE/TIME RELATIONSHIPS	3.594	2.925	- .67
6.	COMMUNICATING	5.297	3.909	-1.39
7.	PREDICTING	4.333	3.423	- .91
8.	INFERRING	4.352	3.690	- .66
9.	DEFINING OPERATIONALLY	4.740	3.821	- .92
10.	FORMULATING HYPOTHESES	4.552	3.308	-1.24
11.	INTERPRETING DATA	4.770	3.651	-1.12
12.	CONTROLLING VARIABLES	3.820	2.887	- .93
13.	EXPERIMENTING	3.611	2.666	- .94
14.	MEMORIZING	3.501	4.591	+1.09
15.	ORGANIZING	4.940	4.384	- .56
16.	APPRAISING	4.524	3.749	- .78
17.	SYNTHESIZING	4.626	3.636	- .99
18.	PROBLEM SOLVING	4.958	3.605	-1.35
19.	MAKING JUDGEMENTS	4.866	3.563	-1.30
20.	APPLYING	5.422	3.502	-1.92

* MULTIVARIATE F-RATIO = 10.35 (20,65), P>.0001

ALL Univariate F-Ratios are statistically significant except for variable #2.